PATENT SPECIFICATION

644,426

Date of filing Complete Specification: Sept. 13, 1948.

Application Date: Aug. 21, 1947. No. 23237/47.

Complete Specification Published: Oct. 11, 1950.

Index at acceptance:—Class 40(ii), D(3a1 : 5c3).

PROVISIONAL SPECIFICATION

Improvements in or relating to Sound Recording and Reproducing Systems

We, IAN IRVINE BOSWELL, a British Subject, of Crawley Grange, Newport Pagnell, Buckinghamshire, GEORGE VICTOR PLANER, a British Subject, of 119, Lansdowne Road, London, W.11, and FELIX ERNEST PLANER, a British Subject, of Addison Electric Company, Limited, of 163, Holland Park Avenue, Kensington, London, W.11, do hereby declare the nature of this invention to be as follows:—

This invention relates to methods and apparatus for the recording of sound and for the reproducing of the sound records and of the sound.

According to a feature of the invention a dielectric material the permittivity of which undergoes a permanent change as a result of the application of an electric field is passed through an electric field which is varied in accordance with the sound to be recorded.

According to a further feature of the invention a dielectric material having a sound record impressed thereon in the form of changes of permittivity of the material is passed between condenser plates so as to vary the capacity between these and the resulting capacity changes are used for the reproduction of the sounds recorded.

According to a still further feature of the invention a record of dielectric material having a sound record impressed thereon in the form of changes of permittivity of the material is passed between condenser plates so as to vary the capacity between these and the resulting capacity changes are used to produce current, voltage or frequency changes which are caused to vary an electric field in accordance with the changes and a dielectric material the permittivity of which undergoes a permanent change as a result of the application of an electric field is passed through the varying electric field to reproduce the sound record.

As the dielectric material to be used according to the invention, fired ceramic materials may be used similar to perovskite and having the general chemical formula A^{++}, B^{++++} O_3, where A may be for instance, barium, calcium, strontium, magnesium or lead and B may be titanium or zirconium. Mixed titanates or combinations of titanates and zirconates have been found to be particularly suitable.

Permanent changes of the permittivity of these types of materials may be effected by the application of a strong unidirectional electric field.

The dielectric material may be incorporated in a carrier consisting of a thread, tape or disc or applied in the form of a coating to a carrier consisting of a tape, wire or disc. The thread, tape or disc in the first case may consist of a thermosetting or thermoplastic resinous material incorporating a finely divided ceramic as a finely divided suspension and the tape, wire or disc in the second case, may be coated with the finely ground ceramic by using a suitable binder such as an insulating varnish or resin. The tape, wire or disc may be of metal.

For the purpose of making a record the carrier impregnated or coated with the dielectric material is passed through a strong electric field upon which the sound modulation to be recorded is superposed.

While it is contemplated that an amplitude type of modulation may be used, the invention is particularly suitable for a pulse type of modulation of the electric field such as that described in our copending Application No. 24237/47 (Serial No. 644,432).

When the sound record has been produced play-back may be effected by passing the carrier of the treated recording medium between the electrodes of an electric condenser acted upon by a constant voltage, when as a result of the changes of permittivity along the carrier a current varying in accordance with the

capacity of the condenser and hence in accordance with the reorded frequency modulation is obtained in the circuit which includes the condenser. In an alternative arrangement the condenser may form part of a resonant circuit, the frequency of resonance of which varies in accordance with the capacity of the condenser.

In the case of a metal carrier material it will be appreciated that the metal may be used as one plate of the condenser suitable connections being provided.

As previously mentioned once a sound record has been obtained this can be used for providing duplicate records by passing the first record in between condenser plates and using the current, voltage or frequency variations in the circuit including the condenser for modulating an electric field through which a further carrier suitably impregnated or coated with the special dielectric material is passed.

Dated this 21st day of August, 1947.
POLLAK, MERCER & TENCH,
Chartered Patent Agents,
134, Cheapside, London, E.C.2,
Agents for the Applicants.

COMPLETE SPECIFICATION

Improvements in or relating to Sound Recording and Reproducing Systems

We, IAN IRVINE BOSWELL, a British Subject, of Crawley Grange, Newport Pagnell, Buckinghamshire, GEORGE VICTOR PLANER, a British Subject, of 119, Lansdowne Road, London, W.11, and FELIX ERNEST PLANER, a British Subject, of Addison Electric Company, Limited, of 163, Holland Park Avenue, Kensington, London, W.11, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to methods of and apparatus for recording sound, for reproducing sound from such sound records and for copying such sound records.

Certain dielectric materials are known which exhibit ferroelectric properties. The term "ferro-electric materials" hereinafter used refers to materials which show spontaneous polarisation in an electric field and which are composed of domains or polar groups which are capable of reorientation. Examples of such materials are barium titanate and its solid solutions, with a number of related compounds. Such materials possess crystalline structures of the perovskite type and have exceptionally high values of permittivity. When subjected to an electric field of suitable intensity permanent changes in the values of permittivity of such materials take place and this is believed to be due to the reorientation of the said domains or polar groups.

According to the broadest aspect of the invention a method of recording sound comprises the steps of forming a carrier body of ferroelectric material as herein defined and of a character such that its permittivity value may be permanently changed as the result of the application of an appropriate electric field, and then passing successive localized areas of such carrier body along a chosen recording path through said electric field while the latter is varied in accordance with the sound to be recorded.

According to another feature of the invention a body of or containing a ferro-electric material as herein defined having a sound record impressed thereon in the form of changes of permittivity of such ferro-electric material is passed between the opposing electrodes of a condenser so as to vary the capacity therebetween and the resulting capacity changes used for the reproduction of the recorded sound.

According to a further feature of the invention a body of or containing a ferro-electric material as herein defined having a sound record impressed thereon in the form of changes of permittivity of such ferro-electric material is passed between the opposing electrodes of a condenser so as to vary the capacity therebetween and the resulting capacity changes used to produce current, voltage or frequency changes which are caused to vary an electric field in accordance with such changes, a ferroelectric material the permittivity of which undergoes a permanent change as a result of the application of an electric field being simultaneously passed through such varying electric field to produce a copy of the original sound record.

For the ferroelectric material to be employed it is proposed to use fired ceramic materials similar to perovskite and having the general chemical formula A^{++}, B^{++++}, O_3, where A may be for instance barium, calcium, strontium, magnesium or lead and B may be titanium, zirconium, cerium, tin and the like. Solid solutions of different titanates or of titanates with other compounds possessing crystal structure of the perov-

skite type have been found to be particularly suitable.

Permanent changes of the permittivity of these types of materials may be effected by the application of a strong unidirectional electric field.

The ferroelectric material may be incorporated in a carrier consisting of a thread, tape or disc or applied in the form of a coating to a carrier consisting of a tape, wire or disc. The thread, tape or disc in the first case may consist of a thermosetting or thermoplastic resinous material incorporating a finely divided ceramic as a finely divided suspension and the tape, wire or disc in the second case may be coated with the finely ground ceramic by using a suitable binder such as an insulating varnish or resin. The tape, wire or disc may be of metal.

The various features of the invention will be more readily understood from the following description of a number of embodiments given by way of example and with reference to the accompanying drawing wherein:—

Fig. 1 is a schematic diagram of a sound recording arrangement according to the invention.

Fig. 2 is a similar schematic diagram of a sound reproducing arrangement according to the invention.

Fig. 3 is a similar schematic diagram of a sound record copying arrangement according to the invention.

Fig. 4 is a schematic diagram of a modification applicable to either of the arrangements of Fig. 2 or 3.

Fig. 5 is a sectional view showing one form of record body construction.

Fig. 6 is a view similar to Fig. 5 of another form of record body construction.

Referring first to Fig. 1, which shows a sound recording arrangement, the record body 10 consisting of or including a ferroelectric material having the aforesaid poperty that its permittivity may be permanently changed as the result of the application of a suitable electric field, is arranged to be moved by means of a driving roller couple 11, 12 driven by a, preferably constant speed, motor 13. The body 10, in its travel, passes between a first electrode 14 and a counterelectrode 15 of a condenser whereby the ferroelectric material forms a major part of the total dielectric subjected to any electric field existent between the electrodes.

The electrodes 14, 15 are connected by way of choke-coils or other suitable impedances 16, 17 to a source of D.C. potential 18 and also to the output circuit of a voltage amplifier 19 whose input circuit is energised by an electro-acoustic transducer, e.g. a microphone 20 subjected to the sounds which are to be recorded.

The D.C. potential source 18 serves to provide an electric field between the electrodes 14, 15 sufficiently strong to effect a permanent change in the permittivity of the ferroelectric material of the record body 10, the sound modulations of output from the amplifier 19 being superposed thereon to cause variation of the changed permittivity value from place to place along the record body 10 in accordance with the sound effective upon the microphone 20, as such body is moved continuously between the condenser electrodes.

Fig. 2 shows a reproducing or play-back arrangement in which the record body 10 carrying the sound record impressed thereon as changes of the permittivity value of the ferroelectric material thereon or therein from place to place, is arranged to be moved by means of a driving roller couple 21, 22 driven by a motor 23, between a first electrode 24 and a counter-electrode 25 of a condenser so as to constitute a major part of the total dielectric subjected to any electric field between the opposing electrode surfaces.

Connected across the electrodes 24, 25 is a series arrangement of a source of constant voltage 26 and a resistor 27. The voltages developed across the latter are applied to the input of an amplifier 28 whose output is fed to a suitable electro-acoustic transducer, e.g. a loud speaker 29.

In the operation of this arrangement the variation of capacity between the electrodes 24, 25 occasioned by the variation of permittivity of the record body 10 at different places thereof passed between the electrodes, causes a current flow through the resistor 27, such current flow being variable in accordance with the originally recorded sound. The resultant changes in potential across the resistor 27 are likewise in accordance with the recorded sound and, after amplification, serve to operate the loudspeaker 29.

In the record copying arrangement shown in Fig. 3 the section A is substantially identical with the reproducing arrangement described above with reference to Fig. 2 with the exception that the amplifier 28, instead of or in addition to supplying a loudspeaker, energises an amplifier 19 of an arrangement B which is otherwise substantially similar to the recording arrangement previously described with reference to Fig. 1. If a number of copies are required to be made simultaneously, further recording arrangements as indicated at C may be supplied in parallel from the amplifier

28. The manner of operation will be self-evident in view of the previous description.

Instead of utilising the variations of capacity set up between the electrodes 24, 25 of Fig. 2 or Fig. 3 in the manner previously described, such condenser may form part of a resonant circuit whose frequency of resonance is varied in accordance with the recorded sound. One such modification is shown in Fig. 4, where the electrodes are connected in parallel with an inductance 30 and a trimmer condenser 31. The resonant circuit constituted by the inductance 30 and condenser 31 and condenser electrodes 24, 25 is arranged as the frequency controlling circuit of an oscillator 32 the output of which is then applied to a frequency-discriminator circuit 33, e.g. of the Foster-Seeley type, whereby an amplitude modulated output corresponding to the original recorded sound is obtained after the manner of conventional F.M. signal receivers.

If desired the resonant circuit 30, 31, 24, 25 may be arranged as part of the modulator of an F.M. radio or carrier transmitter for eventual reproduction of the recorded sound after transmission to a distant point.

While it is contemplated that an amplitude type of input sound modulation may be used for the initial recording, the invention is, however, particularly suitable for a pulse type of modulation of the electric field such as that described in our co-pending Application No. 24237/47 (Serial No. 644,432).

Fig. 5 illustrates one form of record body in which a mass 40 in the form of a thread, tape or disc, of thermosetting or thermoplastic resinous material has incorporated therein finely divided particles 41 of a suitable ceramic material as previously referred to.

In the alternative construction of Fig. 6 the carrier or body 42, again in the form of a thread, tape or disc, is separately coated with finely divided particles 41 of the ceramic incorporated in a suitable binder material 43, such as an insulating varnish or resin.

The body 42 of this embodiment may be of insulating material as before, but is more preferably of metal. The body can then be used as the counter-electrode and the use of a separate electrode as previously described, dispensed with by merely arranging for the requisite electrical connection to the metal body, as by the roller 44 of Fig. 6.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A method of recording sound or other transitory phenomena which comprises the steps of forming a carrier body of ferroelectric material as herein defined and of a character such that its permittivity value may be permanently changed as the result of the application of an appropriate electric field, and then passing successive localised areas of such carrier body along a chosen recording path through said electric field while the latter is varied in accordance with the sound to be recorded.

2. A method of reproducing sound recorded in the form of changes of permittivity at different parts of a body of ferroelectric material as herein defined in which such ferroelectric material is passed between a condenser electrode and a counter-electrode so as to vary the capacity therebetween and the resulting capacity changes used as a controlling medium for further sound reproducing apparatus.

3. A method of copying a sound record impressed in the form of changes of permittivity at different parts of a body of ferroelectric material as herein defined wherein such ferroelectric material is passed between a first condenser electrode and a counter-electrode so as to vary the capacity therebetween and the resulting capacity changes used as a controlling medium for apparatus adapted to provide a controlled variation of an electric field, and wherein a ferroelectric material, having the property that its permittivity may be permanently changed as a result of the application of an electric field, is passed through such varying electric field to produce a copy of the first sound record.

4. Apparatus for recording sound by the use of a ferroelectric material as herein defined whose permittivity may be permanently changed as a result of the application of an appropriate electric field, which comprises a first condenser electrode, a second condenser electrode, means for conveying a body of said ferroelectric material between said first and second electrodes and apparatus, controlled by the sound which is to be recorded, for producing between said electrodes an electric field which is variable in accordance with such sound.

5. Apparatus for reproducing sound from a recording in the form of changes of permittivity at different parts of a body of ferroelectric material as herein defined which comprises a first condenser electrode, a second or counter-electrode, means for conveying the record body of

dielectric material between said first and second electrodes and apparatus, responsive to variation of the capacitance of the condenser constituted by said first and second electrodes for providing an output current suitable for operating an electro-acoustic transducer to reproduce said recorded sound.

6. Apparatus for making a copy of a sound record impressed in the form of changes of permittivity at different parts of a body of ferroelectric material as herein defined which comprises a first condenser electrode, a second or counter-electrode, means for conveying the record body of ferroelectric material between said first and second electrodes, a further electrode and co-operating counter-electrode, apparatus responsive to the variation of capacitance of the condenser constituted by said first and second electrodes for providing an electric field between said further electrode and counter-electrode which is variable in accordance with said changes in capacitance at the first and second electrodes and means for conveying a further body of suitable ferroelectric material between said further electrode and counter-electrode so as to be subjected to the field therebetween.

7. The method or the apparatus as claimed in claim 2, 3, 5 or 6, wherein the first and second electrodes are subjected to a constant potential difference and the resultant current flow variation used as a controlling medium for the further apparatus.

8. The method or the apparatus as claimed in claim 2, 3, 5 or 6, wherein the first and second electrodes are arranged as part of a resonant circuit whose frequency of resonance is varied in accordance with the recorded sound.

9. The method or the apparatus as claimed in claim 8 in which such variable-frequency circuit forms part of an oscillation generator whose output is used as the controlling medium for the further apparatus.

10. The method or the apparatus as claimed in claim 9 in which said variable frequency oscillation output is used to modulate an F.M. signal wave transmitter.

11. The method or the apparatus as claimed in any of the preceding claims wherein the record body comprises a thermosetting or a thermoplastic resinous material incorporating a finely divided ceramic ferroelectric material as a suspension therein.

12. The method or the apparatus as claimed in any of the preceding claims wherein the ferroelectric material is applied as a coating to a supporting body.

13. The method or the apparatus as claimed in claim 12 wherein said ferro-electric coating material comprises a finely ground ceramic mixed with a suitable binder.

14. The method or the apparatus as claimed in claim 13 wherein said supporting body is of metal and is adapted to form the counter-electrode of the condenser.

15. The method or the apparatus as claimed in claim 11, 12, 13, or 14, wherein the ferroelectric material of the produced record is a fixed ceramic material of the general formula A^{++}, B^{++++}, O_3, where A and B are materials of the groups hereinbefore referred to.

16. The method or the apparatus as claimed in claim 15 wherein said material comprises a solid solution of different titanates.

17. The method or the apparatus as claimed in claim 15 wherein said material comprises a solid solution of one or more titanates with other compounds possessing crystal structures of the perovskite type.

18. The method or the apparatus as claimed in any of the preceding claims wherein the record body is in the form of a thread.

19. The method or the apparatus as claimed in any of the preceding claims wherein the record body is in the form of a tape.

20. The method or the apparatus as claimed in any of the preceding claims wherein the record body is in the form of a disc.

21. A sound record comprising a body of or containing a ferroelectric material having areas of differing permittivity along a defined path, such differences of permittivity being in accordance with the recorded sound.

22. Apparatus for recording sound reproducing recorded sound or copying sound records substantially as described with reference to Fig. 1, 2 or 3 or Fig. 2 or 3 as modified by Fig. 4 of the accompanying drawings.

Dated this 10th day of September, 1948.

POLLAK, MERCER & TENCH,
Chartered Patent Agents,
134, Cheapside, London, E.C.2,
Agents for the Applicants.

Leamington Spa : Printed for His Majesty's Stationery Office by the Courier Press.—1950.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies, price 2s. 0d. each (inland) 2s. 1d. (abroad) may be obtained.

644,426 COMPLETE SPECIFICATION

1 SHEET

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1.

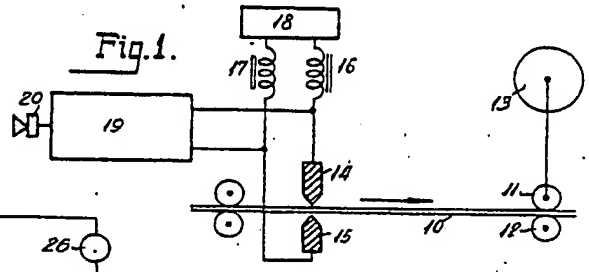


Fig. 2.

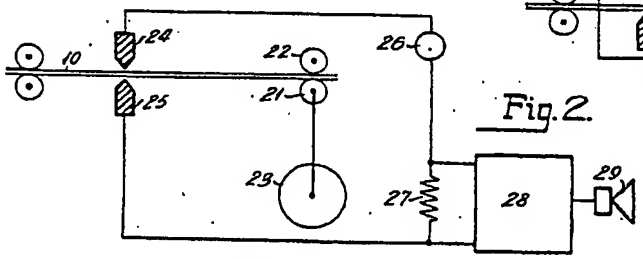


Fig. 3.

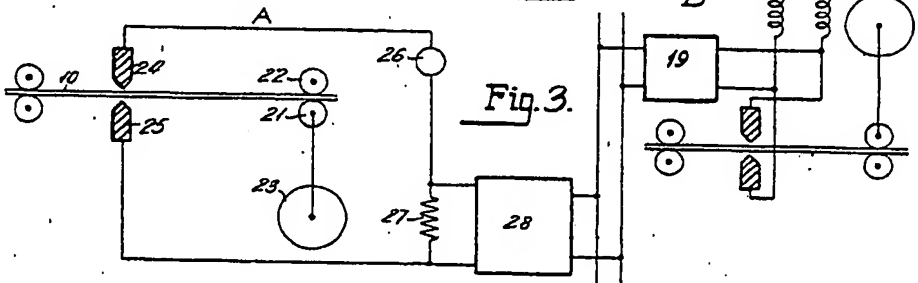


Fig. 4.

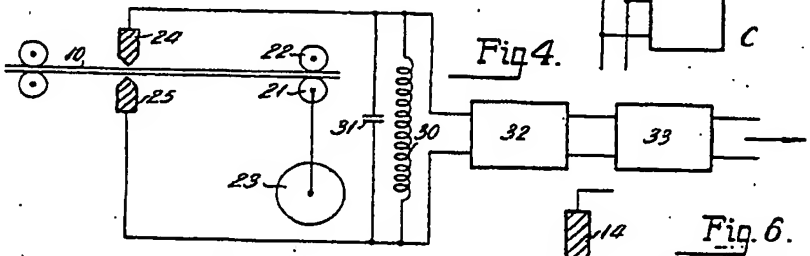


Fig. 5.

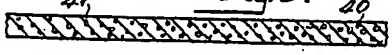
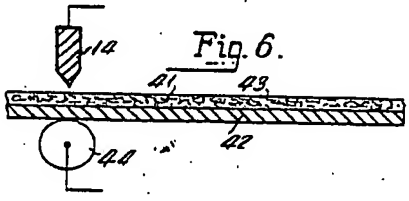


Fig. 6.



H.M.S.O.(Ty. P.)